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Experimental Study On Strength of Concrete Using Nano silica

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Abstract

The test on hardened concrete were destructive test on cube for size (150×150×150 mm) at 7, 14, 28 days of curing as per IS: 516-1959, flexural strength test on beam (100×100×500 mm) at 7, 14, 28 days of curing as per IS: 516-1959 and split tensile strength test on cylinder (100mmφ×200mm) at7, 14, 28 days of curing as per IS: 5816-1999. The primary aim of this study is to assess the effectiveness of silica fume as a pozzolanic material for replacing cement in concrete. It is anticipated that incorporating silica fume into concrete will enhance its strength properties. In this study, the combination of 5% nanosilica and 10%metakaolin which replaced part of the cement had the best results in the Mechanical properties of concrete with a 15% increase in the compressive strength and a 40%increase in the flexural and tensile strength of concrete.

Keywords: *Cylinder block, V8 engine, design, analysis*

1. Introduction

A novel synthetic pozzolanic material, ultra-fine amorphous colloidal silica (UFACS), is now commercially available. UFACS offers potential advantages over traditional silica fume due to its higher content of amorphous silica (>99%) and the smaller size of its spherical particles (1-50 nm). Incorporating UFACS into concrete has improved water permeability resistance and 28-day compressive strength. [1] Its addition to high-strength concrete has enhanced both short-term and long-term strength properties. Moreover, there is a growing emphasis on ensuring that this new concrete technology is sustainable, cost-effective, and energy-efficient, meeting the demands of modern society. These advancements are poised to revolutionize the construction industry. Among the latest innovations in concrete design is using UFACS within the concrete matrix. By integrating UFACS, the formation of strength-bearing crystals in cement paste can be enhanced or controlled. Recent breakthroughs include the ability to examine the atomic-level structure and measure the strength and hardness of microscopic and nanosomic phases in composite materials. Notable discoveries also include the identification of a highly ordered crystal nanostructure within amorphous C-S-H gel. Studies on the hydration of nano-SiO2 in cement paste have been conducted using techniques such as scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDAX). [2]

2. Experimental Methods or Methodology

2.1 Material selection

Cement plays a crucial role in the infrastructure industry, serving various purposes and available in numerous compositions tailored to specific needs. Cements are often named based on their primary constituents, intended applications, target objects, or distinctive properties. For instance, some construction cement [3] are named after their reported place of origin, like Roman cement, while

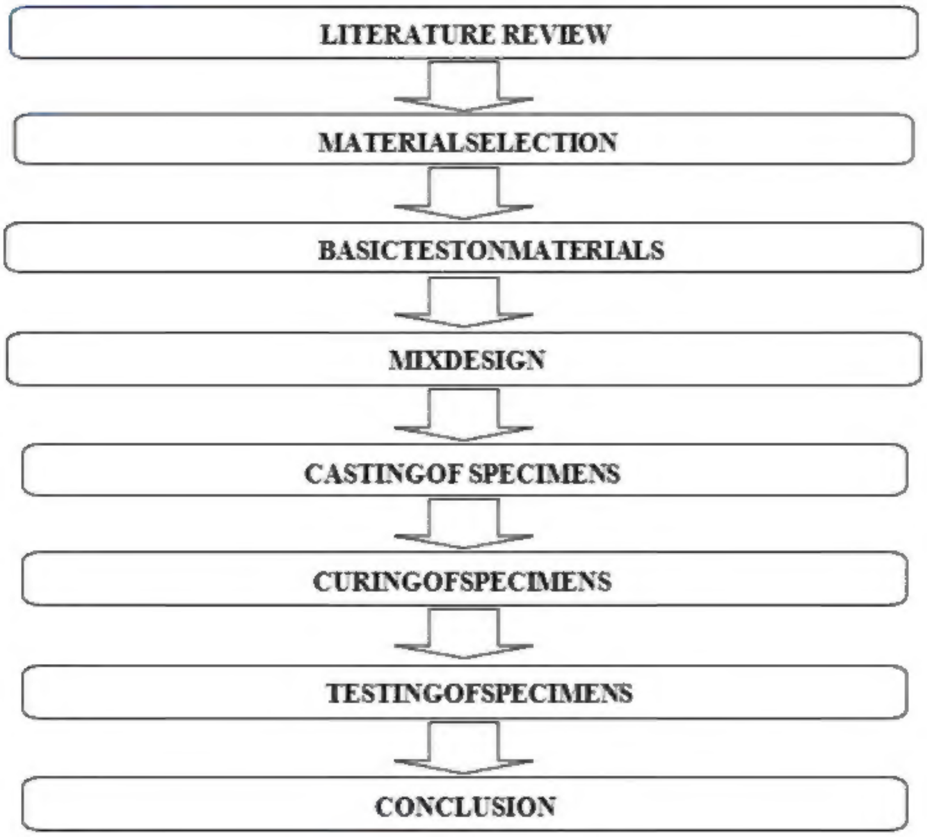

Figure 1 **Methodology**

Others are named for their resemblance to certain materials, such as Portland cement, which produces concrete resembling Portland stone used in British construction. The term "cement" originates from the Latin word "Cementum," referring to stone chippings used in Roman mortar rather than the binding material itself. [4] In a broad sense, cement is described as a substance possessing adhesive and cohesive properties, enabling it to bond mineral Fragments into A solid mass. The reintroduction of cement after the decline of the Roman Empire occurred around 1790, attributed to the discovery by Englishman J. Smeaton. He found that when lime containing a specific amount of clay was burned, it would set even underwater, resembling the cement used by the Romans. Subsequent investigations by J. Parker in the same era led to the commercial production of natural hydraulic cement [5]. Methodology process shown in Figure 1.

Figure 2 **Cement**

2.2 Water

Water plays a vital role in concrete manufacturing. Within concrete mixes, water serves two primary functions: firstly, it chemically reacts with the cement, facilitating the setting and hardening process, and secondly, it lubricates all other components, enhancing the workability of concrete. While water is essential to the concrete mixture, its quality has minimal impact on the overall quality of concrete. Excessive mixing water is a common cause of poor-quality concrete. Essentially, the strength of concrete is determined by the ratio of water to cement in the mix, provided the mixture is plastic and workable, properly compacted, and adequately cured. [6] The cement image is shown in Figure 2.

2.3 Aggregate

Initially, aggregates were viewed merely as a means to reduce the amount of cement needed in concrete. However, it is now understood that the type of aggregate utilized can significantly impact the properties of both fresh and hardened concrete. As aggregates typically constitute 80% of the concrete mix, their characteristics play a crucial role in determining concrete properties. Aggregates are broadly categorized into four types: heavyweight, normal weight, lightweight, and ultra-lightweight. However, in most concrete applications, only normal-weight and lightweight aggregates are employed, with other types reserved for specialized uses [7]. Nuclear radiation shielding in beach concrete. The classification of aggregates for high-quality concrete involves utilizing aggregate in at least two size groups: fine aggregate, commonly referred to as sand and not exceeding 5mm in size, and coarse aggregate, which consists of material at least 5mm in size. Additionally, aggregates possess certain properties, such as particle shape, size, surface texture, and absorption, which significantly influence concrete quality in both fresh and hardened states. While an aggregate may exhibit unsatisfactory characteristics, it may not necessarily cause issues when used in concrete. [8]

2.4 Fine Aggregate

Fine aggregate, also known as material passing through an IS sieve with a size of less than 4.75 mm, is typically sourced locally and predominantly consists of natural sand. In areas where natural sand is unavailable, crushed stone is commonly used as a substitute for conventional concrete. For this study, River Sand Zone II was utilized as the fine aggregate, and various test results are provided in a table format. As per the standards outlined in 383:1970, fine aggregate is classified into four distinct zones: Zone I, Zone II, Zone III, and Zone IV. It's important to note that there isn't a specific chemical formula for sand, but it's generally considered primarily composed of SiO_2 (silica) and various other minerals. Sand exhibits a range of colors depending on its geographical location and composition. [9] It consists of a mixture of Silica (SiO_2), Calcium Silicate ($CaSiO_4$), Calcium Nitride (Ca_3N_2), Silicon Nitride (Si_3N_4), Aluminum Nitride (AlN_3), Alumina (Al_2O_3), Borazon (Boron Nitride, BN), Magnesium Oxide (MgO), Silicon Ox sulfide (SiOS), Lithium Silicate (Li_2SiO_4), and other oxides/nitrides of numerous metals [10,11] Fire Aggregate shown in Figure 3.

Figure 3 Fine Aggregate

2.5 Coarse Aggregate

The form and size distribution of the aggregate play a crucial role as they impact packing, voids content, water absorption, grading, and fines content variation. Continuous and meticulous monitoring of all aggregate properties is essential to ensure

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consistent quality. In this experimental study, coarse aggregate with a maximum size of 20mm was utilized.

2.6 Nano Silica Fume

Silica fume, often referred to as micro silica, is an ultrafine powder obtained as a byproduct during the production of silicon and ferrosilicon alloys. It comprises spherical particles with an average diameter of 150nm. Its primary use is as a pozzolanic material in high-performance concrete applications. Nano Silica aggregate image shown in Figure 4.

Figure 4 Nano Silica Fume

2.7 Met kaolin

Met kaolin, derived from the dihydroxylation of the clay mineral kaolinite, finds frequent application in ceramic production. Additionally, it serves as a Substitute for cement in concrete formulations. Notably, met kaolin possesses a smaller particle size and greater surface area compared to Portland cement, albeit larger than silica fume Met kaolin Powder shown in Figure 5.

Figure 5 Met kaolin Powder

3. Results and Discussion

3.1 Compression Test

Apply the load increasingly at a rate of 140 kg/cm² per minute until the cube collapses in Table 1. Note down the maximum load applied to the specimen and any other unusual activities at the time of failure [12].

Table 1 Comparative compression test

Day	Conventional concrete[MPa]			nS concrete[MPa]		
	1	2	3	5%	10%	15%
7	10.5	11.31	12.33	20.8	22.5	21.67
14	16.78	16.93	17.11	26.54	27.6	25.45
28	27.33	27.9	27.66	37.45	40.45	38.33

3.2 Split tensile strength test on cylinder

Clean the bearing surfaces of the supporting and loading rollers thoroughly, removing any loose sand or debris from the specimen's contact areas with the rollers. Document the maximum load applied by the testing apparatus upon Table 2 failure. Take note of the type of failure and observe the fracture's appearance [13].

Table 2 Comparative split Tensile Test

.Day	Conventional concrete[MPa]	nSconcrete[MPa]				
	1	2	3	05%	10%	15%
7	0.93	0.98	1.01	1.9	2.40	2.25
14	1.18	1.36	1.38	2.30	2.75	2.43
28	1.97	2.12	2.33	2.85	3.18	3.09

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3.3 Water Absorption Test

To conduct the water absorption test in Table 3, the specimen was weighed both before and after being submerged in water for a set period. The difference in weight before and after immersion, relative to the initial weight of the specimen, was then calculated to determine the water absorption percentage [14].

Table 3 Comparative Water Absorption Test

uratio n	Conventio nal Concrete	%increa se	nS-concre te	%Increa se
0	8.310	0	8.614	0
30mi n	8.320	0.12	8.619	0.06
60mi n	8.330	0.24	8.619	0.06
1day	8.344	0.40	8.623	0.10
2days	8.347	0.44	8.624	0.11
3days	8.348	0.45	8.625	0.12

Conclusion

Tests were conducted on cubes, cylinders, and beams to evaluate compressive, split tensile, and flexural strength. The results indicated an increase in strength across all parameters [15]. The effects of various ratios of Nano-Silica to cement content were thoroughly investigated, with the optimal ratio identified as 3%. Based on the findings, several key points regarding silica fume concrete can be concluded: Silica fume enables the production of concrete with exceptionally high early-age strength. Strengths of up to 200 MPa can be achieved with the incorporation of silica fume. Results from water absorption tests suggest that concrete containing Nano-silica is more durable than conventional concrete. Additionally, the addition of Nano-silica enhances resistance to permeability in concrete [16].

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